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Optimization of Conductor Wire Rope for different Testing and Generation of Common Test Set Up

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Abstract: Generally, wire ropes are used in many industries with application that include mining, off-shore oil production, and towing or mooring ships. Wire ropes are also used extensively in such diverse transportation application as ski-lifts, cable cars, bridges, cranes and elevators. Premature failure of ropes can be costly in any application. In mining, the human costs due to the premature failure of rope can be devastating.

I will try to focus on the modelling and analysis of wire rope for conductor line considering the pole distance and sag of the wire rope, further comparing the simulated line considering the pole distance and sag of the wire rope, further comparing the simulated results with the theoretical, and trying to make a common set up for the whole test.

Keywords: Wire rope, creo, tensile load, transmission line, static analysis

I. INTRDUCTION

Wire rope is a type of rope which consists of several strands of metal wire laid (or 'twisted') into a helix. Initially wrought iron wires were used, but today steel is the main material used for wire ropes.

Wire Strands and ropes are used in variety of engineering applications due to their high strength-to-weight ratio and very efficient use of the material. These characteristics are of particular significance in the design of lightweight suspended structures and large-span cable-stayed bridges. Wilhelm Albert's first ropes consisted of wires twisted about a hemp rope core, six such strands then being twisted around another hemp rope core in alternating directions for extra stability. Earlier forms of wire rope had been made by covering a bundle of wires.

Manufacturing a wire rope is similar to making one from natural fibers. Fig 1.2 shows basic wire rope i.e. the individual wires are first twisted into a strand, and then six or so such strands again twisted around a core to construct a wire rope. This core may consist of steel, but also of natural fibers such as sisal, manila, henequen, or hemp. This is used to cushion off stress forces when bending the rope.

This flexibility is particularly vital in ropes used in machinery such as cranes or elevators as well as ropes used in transportation modes such as cable cars, cable railways, funiculars and aerial lifts. It is not quite so essential in suspension bridges and similar uses. *(Ref.6)*

Wire rope is a highly specialized precision product which is adaptable to many uses and to varied conditions of operation. To meet the exacting requirements of different types of service, it is designed and manufactured in a number of constructions and grades.

Wire rope is a complex machine, composed of a number of precise, moving parts which are designed and manufactured to bear a very definite relationship to one another. In fact, many wire ropes contain more moving parts than most mechanisms that fall within the broad general term of machines. For example a six-strand rope, consisting of approximately 46 wires per strand, contains a total of 276 individual wires, all of which must be able to move with respect to one another if the rope is to have the necessary flexibility during operation.

II. DIFFERENT ROPE DESIGN CONSTRUCTION

1) *Single Layer:* The most common example of the single layer construction is a 7 wire strand. It has a single-wire center with six wires of the same diameter around it. Shown in Fig 1.6 (a)
2) *Seale:* This construction has two layers of wires around a center with the same number of wires in each layer. All wires in each layer are the same diameter. The strand is designed so that the large outer wires rest in the valleys between the smaller inner wires. Example: 19 Seale (1-9-9) strand. Shown in Fig 1.6 (b)
3) *Warrington:* This construction has two layers of wires around a center with one diameter of wire in the inner layer, and two diameters of wire alternating large and small in the outer layer. The larger outer layer wires rest in the valleys, and the smaller ones on the crowns, of the inner layer. Example: 19 Warrington [1-6-(6+6)]. Shown in Fig 1.6 (c)

4) *Filler Wire:* This construction has two layers of uniform-size wire around a center with the inner layer having half the number of wires as the outer layer. Small filler wires, equal in number to the inner layer, are laid in valleys of the inner layer. Example: 25 Filler Wire (1-6-6f -12) strand. Shown in Fig 1.6 (d)
5) *Combined Patterns:* When a strand is formed in a single operation using two or more of the abo constructions, it is referred to as a "combined pattern." This example is a Seale construction in its first two layers. The third layer utilizes the Warrington construction, and the outer layer is a Seale construction. It's described as: 49 Seale Warrington Seale [1-8-8-(8+8)-16]. Shown in Fig 1.6 (e)

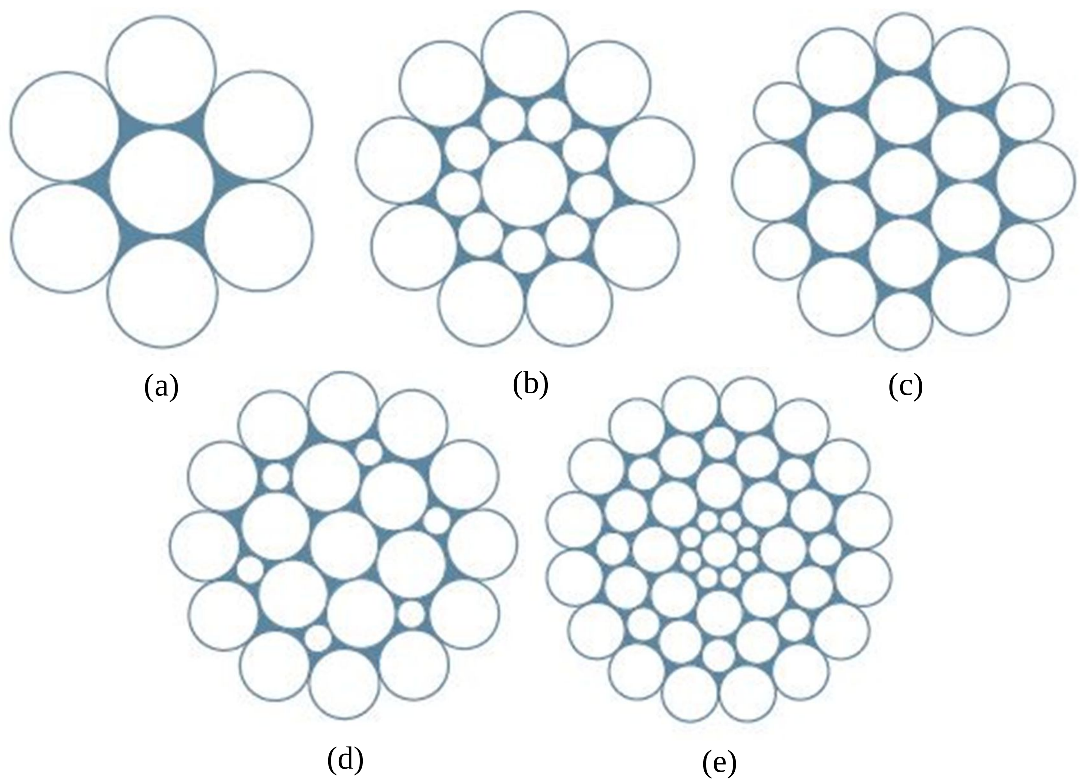

Figure 1.6: Different wire rope design construction (name, year)

A. Wire Rope Measurements

1) *Pitch or Length of Lay:* The length of a rope lay is that distance measured parallel to the axis or centerline of a rope in which a strand makes one complete spiral or turn around the rope. The length of a strand lay is the distance measured parallel to the axis or centerline of the strand in which one wire makes one complete spiral or turn around the strand as illustrated in Fig 1.9. *[Ref.13]*

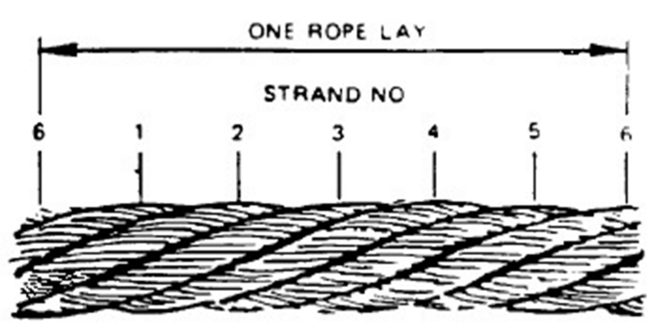

Figure 1.9: Length of rope lay (Naval ship's technical manual chapter 613)

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2) *Size:* The diameter of a wire rope is the diameter of the circle which will just enclose all of the strands. In the case of strands, the diameter is that of the circle which will just enclose all of the wires. The correct diameter is the greatest diameter of the rope or strand. Figure 1.9 shows the correct and incorrect ways of measuring wire rope.

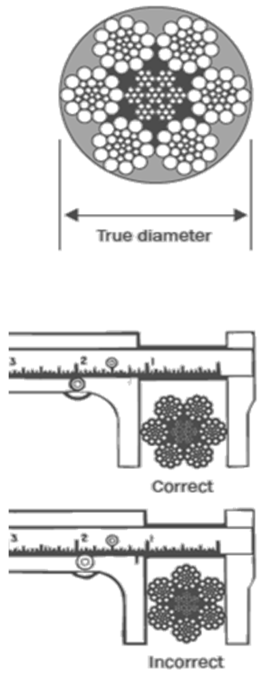

Figure 1.10: Correct and incorrect ways of measuring wire rope (name, year)

III.GEOMETRICAL MODELING OF WIRE ROPE

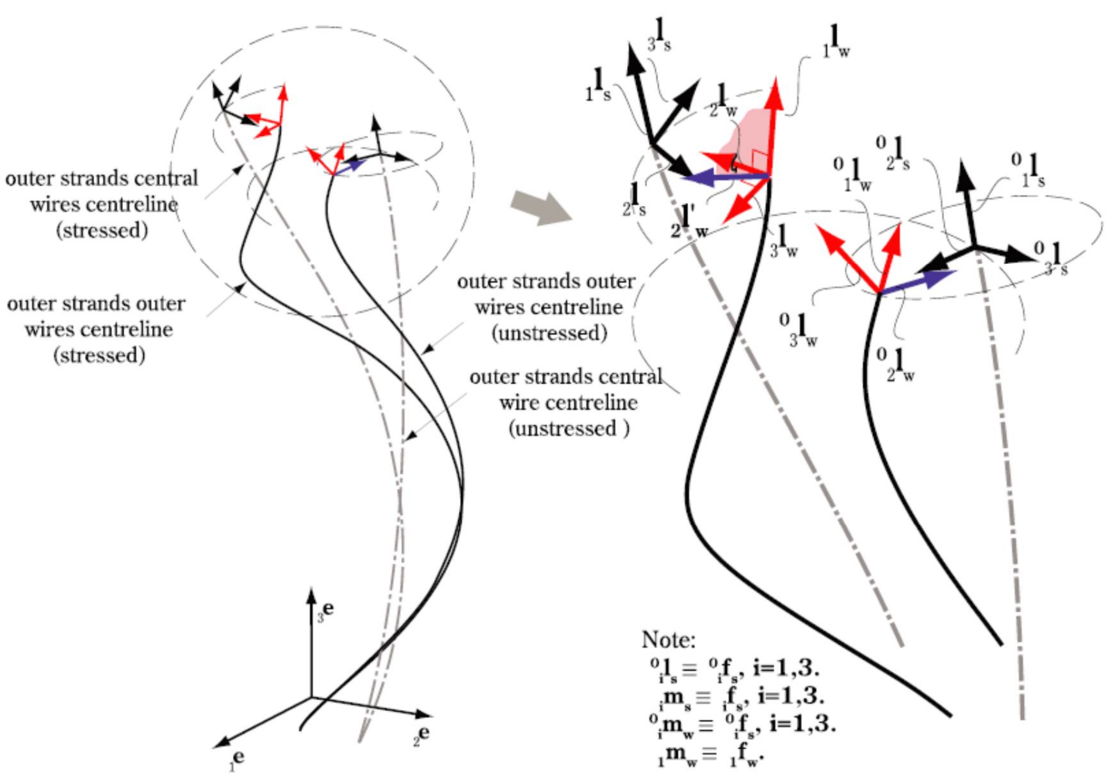

Figure 2.5: Description of the considered kinematics. [Usabiaga and Pagalday 2008]

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Wire ropes are used in many application areas such as bridges, cranes, elevators etc. To learn the characteristics of wire ropes forces to make empirical tests. However, this is not so practical and expensive task to conduct empirical tests over wire ropes. Instead of this numerical analysis can be done using the three dimensional solid model of wire ropes. A simple straight strand is one of the basic components of wire ropes. Strands are wrapped around a simple straight strand to produce a more complicated wire rope and named as independent wire rope core (IWRC). IWRC is used as the core strand of Seale and Warrington type wire ropes. In this paper first modeling of wire strand and IWRC using helical and nested helical geometry is done. Then a finite element analysis using the nested helical structure is developed using the 3-D solid model of IWRC. At the end of this paper empirical test procedure is described with the fundamental components of materials designed for this purpose and the test results of IWRC is presented.

Designing and modeling the wire rope is a difficult issue due to the complex nature of the wire ropes. Independent wire rope core (IWRC) is used as a core strand for some special kind of ropes such as Seale and Warrington IWRC's. It is composed by a straight core strand, which is helically wrapped by six outer strands. Center strand and outer strand of an IWRC comprise totally four different diameters of wires. Meanwhile the design of IWRC's includes three different types of wire centerlines. A straight wire with radius 1 R which is the center wire of the core strand, single helical wires with helix radiuses 2 R and 3 R which are located as the outer wires of the center straight strand and the center wire of the outer strands respectively, and the third type of wires with radius 4 R are the nested helical wires wrapped around the center single helical core wire of the outer strands as shown in Fig. 2.6.

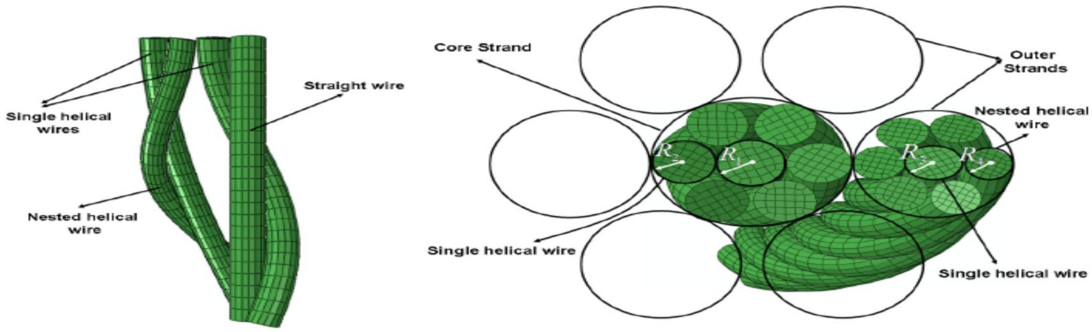

Figure 2.6: Cross sectional view of an IWRC with different wire centerlines [Erdonmez et. al. 2010]

IV. RESULTS AND DISCUSSION

Now we are comparing bending analysis results, table showing simulated and theoretical results.

Sr. No.	Rope Length	Simulated Bending Deformation in [mm]	Theoretical Bending Deformation in [mm]
1	50	0.00006	0.0075
2	100	0.00091	0.0604
3	150	0.00411	0.2038
4	200	0.01067	0.4830
5	250	0.02137	0.9434
6	300	0.38954	1.6302
7	350	0.72176	2.5888
8	400	1.23140	3.8643
9	450	1.97270	5.5021
10	500	3.00690	7.5474
11	550	4.40270	10.0456
12	600	6.23580	13.0419
13	650	8.58940	16.5816
14	700	11.5540	20.7101
15	750	15.2260	25.4725
16	800	19.7110	30.9141

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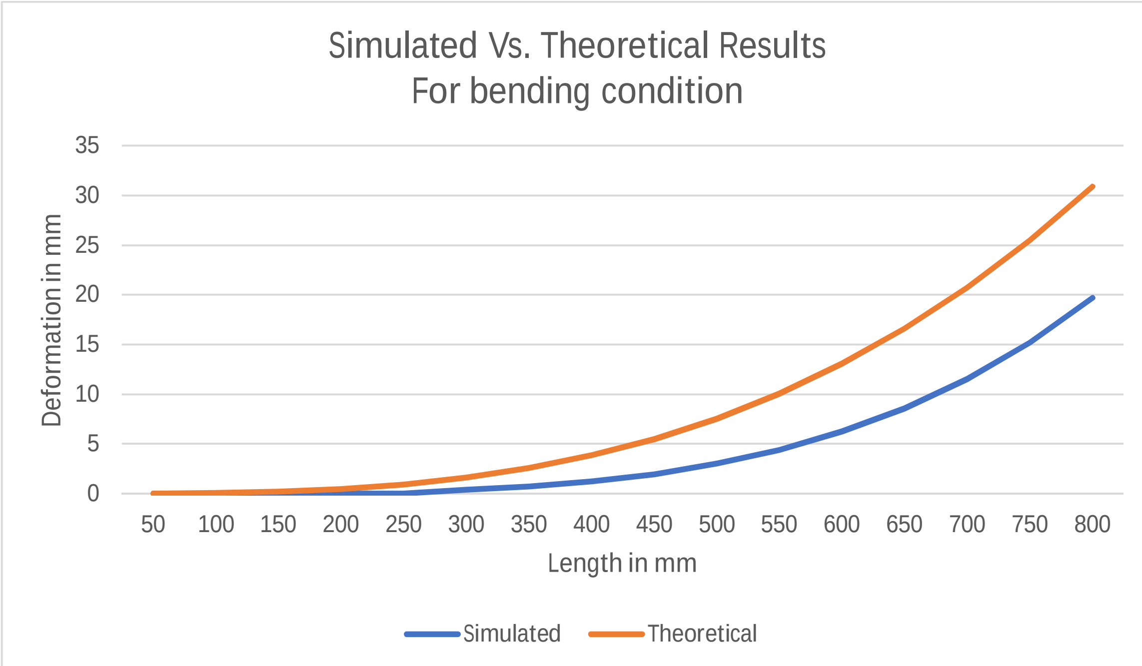
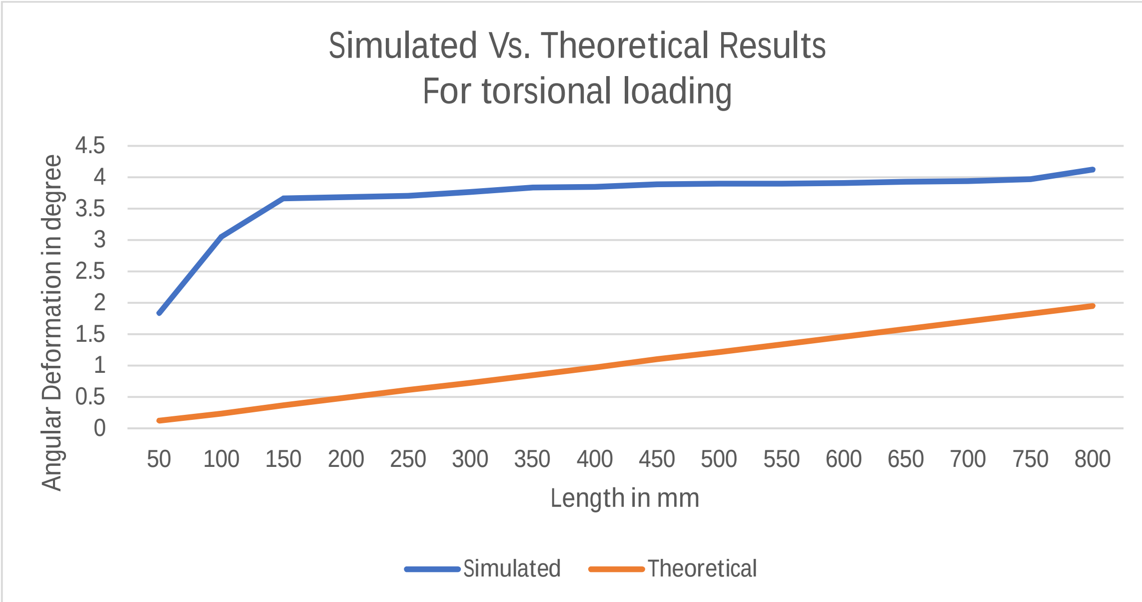


The plotted results are showing very smooth curves for both analysis theoretical and simulated.
Plotted curve are similar to each other but slightly different in showing deformation, simulated curve showing small deformation in wire rope as compare to theoretical deformation curve. Because of inter wire contact are frictional that's why the rope has gain some stiffness in rope wires. Theoretical analysis were performed considering wire rope as cantilever beam.

A. Comparison Of Results For Torsional Or Angular Deformation

Now we are comparing torsional analysis results, table showing simulated and theoretical results.

Sr. No.	Rope Length	Simulated Angular Deformation in [Degree]	Theoretical Angular Deformation in [Degree.]
1	50	1.8344	0.12
2	100	3.0497	0.24
3	150	3.6631	0.37
4	200	3.6900	0.49
5	250	3.7032	0.61
6	300	3.7662	0.73
7	350	3.8408	0.85
8	400	3.8465	0.97
9	450	3.8866	1.10
10	500	3.8981	1.22
11	550	3.9038	1.34
12	600	3.9153	1.46
13	650	3.9325	1.58
14	700	3.9382	1.71
15	750	3.9669	1.83
16	800	4.1274	1.95



The theoretical curves results are showing linear curve for angular deformation in degree because theoretical model was considered as a cylinder that's why it linear. While simulated results are showing variation in angular deformation because actual wire model consider in analysis and the individual wire in contact and the geometry becomes more complicated.

V. CONCLUSIONS

The proposed modeling and simulation procedure permits to select the objective function of greatest interest for the designer of wire rope. From the analysis previously presented in this thesis, the following conclusions may be noted:

1) In order to precisely model the complex geometry of helical wire strands and ropes necessary for their finite element analysis, the calculation has been done and further analyzed in CREO 2.0 software code for the geometric modelling. The methodology of their implementation and the approach for creation of the geometric model for the strand were demonstrated.
2) To predict the behavior of wire rope strand under tensile loading, bending loading and torsional loading geometrical models has been implemented in a finite element program. For this purpose ANSYS software was used. The finite element analysis has been done in static structural solver using individual system for each geometric model.
3) In comparison with previous analysis of wire strands reported in the literature where obviously single-layered strands with a construction of 1 + 6 wires were modelled and analyzed, this dissertation was focused on the wire rope strand with construction of 1 + 6 wires considering frictional effects between individual wires.
4) The derived three dimensional geometric models of wire rope strands and the results of the present finite element analysis were validated through comparisons with experimental and theoretical data available. The obtained results confirm the correctness of the mathematical and physical importance of the finite element model developed.
5) It is observed that the deformation obtained at various length against maximum force is almost linear and the wire rope material follow proportional limit under the considered load.

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